is our belief that if these are kept in mind, electroencephalography will find its proper place as a useful adjunct in the practice of medicine.

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THE EARLY DIAGNOSIS OF EXPANDING LESIONS OF THE BRAIN*

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Saskatoon

ALL expanding lesions of the brain raise the intracranial pressure and, therefore, produce a certain group of similar symptoms. I shall use the word "tumour" frequently and, by it, I shall mean a swelling, rather than in the more restricted sense of neoplasm.

The diagnosis of an intracranial expanding lesion is not necessarily difficult, if one does not mean too much by "diagnosis". It is my contention that a man in general practice has made a splendid diagnosis if he refers a case to a neurosurgeon with the diagnosis of a tumour of the brain, and later the neurosurgeon uncovers any expanding lesion within the cranial cavity. The neurosurgeon should localize the lesion. One immediately asks "what is early?" I consider in neurosurgery that a case is diagnosed early, when, because of pressure, there has been no irrecoverable loss of vision, or other damage which release of pressure will not almost completely repair. Also, the diagnosis must be made early enough that the patient is still in a condition to withstand the procedures necessary to attack the lesion. One can understand that a rapidly growing tumour (Fig. 1) or one blocking the ventricular system may be diagnosed too late and yet only be a few months old; while, a slowly growing meningeal fibroblastoma (Fig. 2) may be early years after its commencement.

If you were to ask me how best to generally prepare oneself to diagnose tumours of the brain, I would say. (1) Have a working knowledge of the anatomy of the brain and central nervous system, and an understanding of the localization of functions of the cortex. (2) Learn to take a proper chronological history from the patient, and also how best to question both the patient and someone else who has been close to him. (3) Carry out a systematic neurological examination in every case. (4) Learn to use an ophthalmoscope.

Of the last 100 expanding lesions of the brain upon which I have operated, a number of conditions have been disclosed.

1. Tumour of the brain	76
2. Abscess of the brain	7
3. Subdural hæmatoma	9
4. Intracerebral hæmorrhage	2
5. Intracranial aneurysm	1
6. Œdema of the brain	3
7. Arachnoiditis with cyst (posterior fossa)	2
Total	100

Once a lesion commences to enlarge within the cranial cavity, naturally it occupies space which was previously occupied by functioning tissues. There are only four elements in the brain: (1) nerve cells; (2) intracellular tissue; (3) blood vessels containing blood; and (4) cerebrospinal fluid. Symptoms are caused by

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the compression of the nervous tissue delaying or resulting in a complete cessation of its function, or by the collapse of the blood vessels with consequent lack of circulation to nerve structure. All symptoms must arise from these phenomena, directly or indirectly. Increased intracranial pressure results in certain signs and symptoms.

General Signs and Symptoms

1. *Headache.*—Headache is the most frequent complaint. Confronted with a patient complaining of headache, it is the duty of the doctor in charge to rule out the possibility of a space-occupying lesion of the brain. The actual pain is most likely due to tension upon the dura. I have not found that the position of the pain is diagnostic, nor have I found the headache to be different from other headaches. Frequently, the headache is first noticed early in the morning. However, one must remember that tumours do occur without headache, especially if very slowly growing, and in children whose sutures are still capable of being separated. Sometimes soft infiltrating tumours which replace brain tissue cause little or no headache. Also, when there is no obstruction to the flow of cerebrospinal fluid headaches are not so severe. Consequently, a tumour far forward in a frontal lobe may attain great size without headache; while a tumour in the vermis of the cerebellum, because of obstruction to the aqueduct of Sylvius, may cause intolerable pain quite early. Headache, therefore, is a symptom general in character, but it may be an early indication of a tumour of the brain.

2. *Vomiting.*—Vomiting occurs in a considerable number of cases, but it has been my experience that it occurs most often in posterior fossa tumours and in rapidly growing neoplasms, especially where there has been a sudden almost complete block of the ventricular system. I think vomiting represents Nature's way of dehydrating the patient. I have not found that the vomiting is projectile. When vomiting is an outstanding feature, the patients rapidly lose weight and, of course, become weak. I have had one patient who lost 30 lbs. in four weeks due to vomiting from a tumour blocking the fourth ventricle. I have also had a patient who was operated on for an obstructive duodenal ulcer, but who, following a gastro-enterostomy, still vomited; he was reoperated on to investigate the cause, but nothing was found; I removed a cerebellar tumour weighing 60 grams. Therefore, vomiting is a symptom which must be taken seriously into the picture, and can be an early indication in a diagnosis.

3. *Papillœdema.*—This, to me, is the most important single symptom and should always be carefully searched for, especially where there is headache and vomiting. Unfortunately, it is not always present or recognized at its commencement. In an attempt to diagnose lesions earlier I have come to place more and more stress upon the changes in the relative size of the veins and arteries. Usually, by the time the papillœdema has advanced to the stage where the disc is almost obliterated, with radiating hæmorrhages, dipping vessels, and crippled vision, there should be very little doubt in any observer's mind that the patient has an expanding brain lesion. I must admit that sometimes these changes occur rapidly, and also it is well known that there may be no complaints of visual acuity, even in the presence of three or four dioptres of papillœdema.

I wish here to state again how valuable it is to be able to use an ophthalmoscope properly, and it is good practice to look at every disc possible to be able to appreciate what is normal in patients of different ages and complexions. I have in mind two cases upon which I have operated lately. One, a young woman of 27 years of age, with a medullablastoma of the fourth ventricle; the other, a boy of 17 years of age, with a large astrocytoma of the right cerebellar lobe. Each of these patients came to me with advanced papillœdema as well as some atrophy of the discs. The young woman could recognize objects moving in a room; the boy could not distinguish daylight from dark. The first case had been diagnosed for months as a neurosis, and the second one as "gastro-neurosis" because of vomiting. I do not mention the diagnosis with any derogatory implication, but only to show how one may be led astray. Although I was able to remove both tumours and each patient made a good recovery, they are and will remain visual cripples. I am certain that studied examination of the optic discs would bring many of these cases to operative aid at an earlier date.

4. *Epileptic seizures.*—Anyone over 35 years of age who develops epilepsy should be sus-

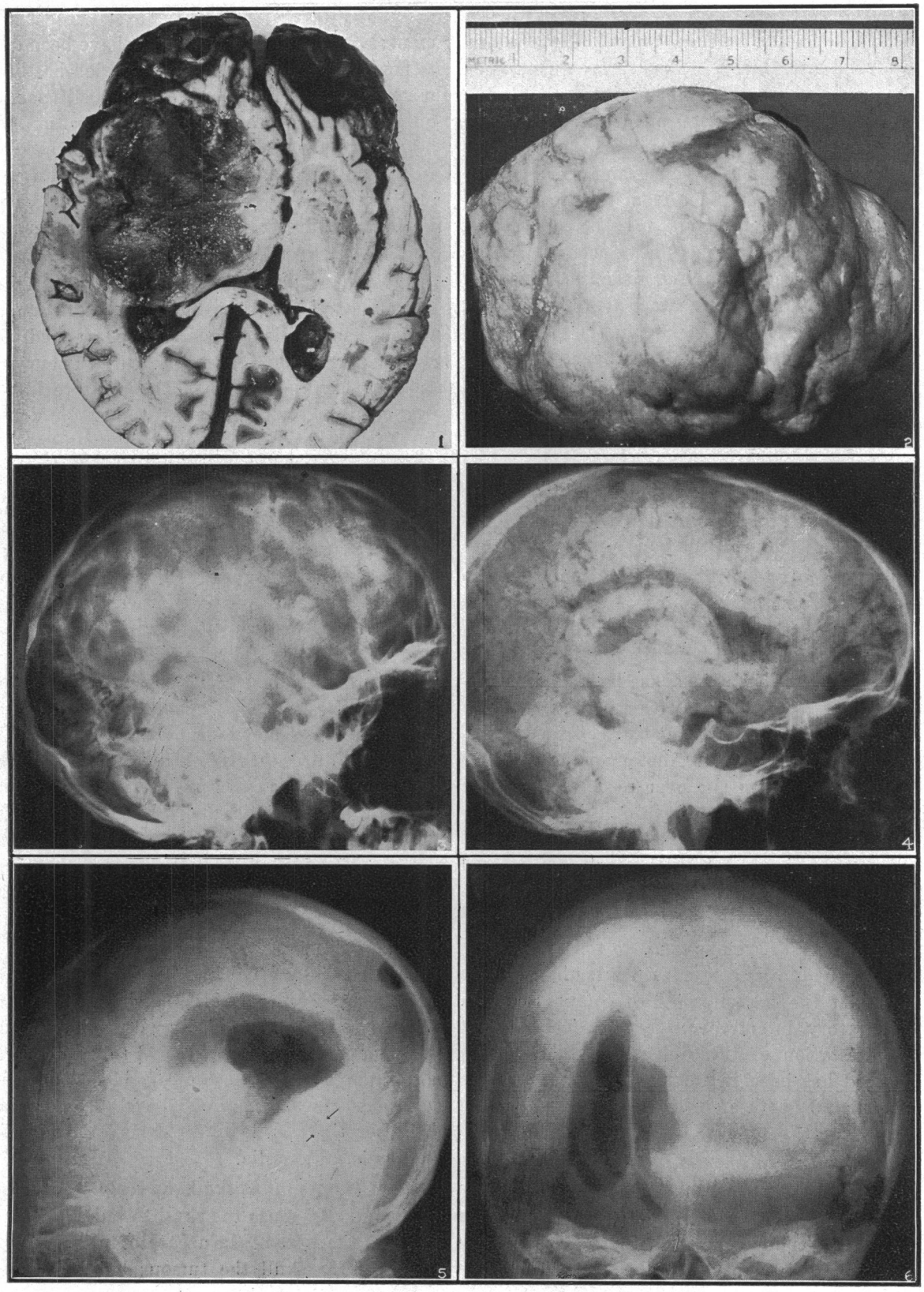

Fig. 1. Case No. 4349-35.—Mr. T.P., age 53. Photograph of a spongioblastoma multiforme, of only a few months' duration. Already it has infiltrated a large portion of one cerebral hemisphere. **Fig. 2.** Case No. 4502-35.—Mr. S.P., age 55. Photograph of a meningeal fibroblastoma, weighing 178 grams. This tumour had been causing seizures for 6 years with gradual left sided paralysis and anæsthesia. It was removed August, 1935. He has had no epileptic seizures since, but has some slight residual paralysis. **Fig. 3.** Case No. 2627-38. —Miss L.L., age 14. Film showing calcification in a tumour as well as convolutional atrophy. **Fig. 4.** Case No. 4439-34.—Mr. J.L., age 39. This lateral stereo demonstrates a definite lifting of the left lateral ventricle. A diagnosis of a thalamic tumour was made, and no operative attack was carried out. Necropsy later proved the diagnosis. **Fig. 5.** Case No. 872-38.—Mrs. R.P., age 27. I diagnosed this case as a third ventricle tumour, but was not satisfied. A re-injection of air with careful posturing showed the aqueduct of Sylvius dilated and pushed backwards. Operation disclosed a tumour (medullablastoma) blocking the 4th ventricle and occupying part of the right cerebellar hemisphere. **Fig. 6.** Case No. 3827-35.—Mr. F.M., age 58. This film shows a gross displacement of the ventricular system with the 3rd ventricle slanted and dilated. At operation, a huge sub-dural hæmatoma was disclosed.

pected of having a brain tumour. Hyland and Botterell and Harry L. Parker lay stress upon the same point. The location of the lesion sometimes may be determined from the aura produced. However, a nodule of a tumour, by causing a tug upon a vessel and "firing" the seizure at some distance from the most prominent part of the tumour, may be misleading. In my experience seizures have occurred where the tumour was through or near the surface of the cortex, or when attached to the dura. Seizures, therefore, may aid in the early diagnosis, as they may be the initial symptom.

5. *Paralysis of the 6th cranial nerve.*—This results in inability to turn the eye outwards. Cushing has shown that this symptom is the result of increased intracranial pressure, and is not necessarily of localizing value. Sachs states that bilateral 6th nerve paralysis localizes a tumour in the pons.

6. *Vertigo and dizziness.*—It is important to determine whether changes of position of the head cause these symptoms. I diagnosed a third ventricle cyst in this manner. When the patient leaned backwards she became fearfully dizzy. (I use the term "fearfully", because it frightened her.) She had to sleep face downward to be comfortable. Another patient told me the first symptom she ever noticed was when she stooped down to open a drawer in her pantry. She had a cerebellar tumour. No doubt the change of position resulted in altered pressure against the vestibular mechanism.

7. *Respiratory disturbances.* — When intracranial pressure is increased to the extent that the cerebellum is compressed into the foramen magnum the medulla is also compressed and respiratory interference occurs. The earliest manifestation of these changes which I have noticed has been in reference to variations in length and depth of inspiration, rather than in rate.

8. *Changes in mental activity.*—Because of the increased intracranial pressure there may be gradual slowing of cerebration. A number of these patients commence their illness by appearing to be mentally duller. They lack the power to concentrate, and lose interest in their work and surroundings. It is often very valuable to have an assessment of the change by some observant relative, because the patient may or may not recognize even advanced mental changes. These patients have been sent to mental institutions as the condition has been mistaken for a psychosis. Administration of 50 per cent glucose or 10 per cent saline may be used to show if the mental changes are due to a local lesion in the frontal lobes or to general pressure. If due to generally increased intracranial pressure the mental symptoms may be temporarily relieved.

9. *Sudden unconsciousness or coma.*—These symptoms may be the result of a brain tumour which has suddenly completely blocked the ventricular system or to a ruptured aneurysm, or they may be due to a hæmorrhage into a cyst connected with a brain tumour. No doubt, in the absence of a post-mortem, apoplexy has been the diagnosis given in many a death where the real cause was a tumour of the brain.

10. *Slowing pulse.*—Because of pressure exerted against the medulla there may be slowing of the pulse to 50 or less. This has seldom been present in cases of neoplasms that I have examined. I believe it is more likely to occur where the pressure is sudden. In one case of a ruptured aneurysm with intraventricular hæmorrhage the pulse went down to 44; upon aspirating the blood from the ventricle the pulse rose to 70. I have also noticed the pulse of brain abscess cases to be slower. Walshe states that slow pulse is by no means common but is more frequently seen in subdural hæmatoma. Of course, one must remember that some persons normally seem to have a slow pulse rate.

11. *Blood pressure changes.*—I have failed to find any diagnostic factors in blood pressure changes in slowly growing lesions of the brain. If the pressure rises rapidly within the cranium the blood pressure also rises. I think, however, that the whole subject of blood pressure changes is more complicated and depends upon whether there is definite œdema in the region of the basal ganglia.

12. *Changes in the skull and scalp.*—A tumour may actually cause the skull to bulge upon the side of the lesion. In a case of primary myeloma of the skull the tumour bulged through an opening in the bone. Angiomatous tumours may demonstrate themselves by huge veins in the scalp. I shall deal with special changes in the skull, as seen by x-ray films, further on in this paper.

Focal Signs and Symptoms

Frontal Lobe:—

1. *Changes in personality and ability of the mind.*—My experience has been that often the very first sign of a far frontal lobe lesion has been a change in the patient's attitude toward his work and surroundings. This may require careful and judicious questioning on the part of the doctor, but I assure you it is worth while. One woman whom I studied commenced her illness by showing slight disregard toward her household duties. She left dirt in the corners when sweeping, and did not mind a few crumbs on the table. Her husband stated that previously she had been a very careful and clean housekeeper. Eventually, I removed a meningeal fibroblastoma weighing 78 grams from her right frontal lobe. One of her nurses visited her last summer and felt that she was back to normal.

Another patient, a farmer who took great pride in his horses and was accustomed to showing them at the surrounding village fairs commenced losing interest by being careless about grooming these animals. Before I saw him he had no interest in his farm at all, and gradually became quite different in his personality. He would frequently make obscene remarks and thought nothing of exposing himself. At operation, I removed a tremendous subdural hæmatoma (Fig. 6) compressing most of his left frontal lobe.

2. *Paresis or paralysis.*—Paresis or paralysis may involve the face, arm or leg of the opposite side, but an important, often early, symptom is lower facial weakness of the opposite side. It may not be demonstrated as clearly if asked for by having the patient show his upper teeth, or in other emotional tests, as when the patient is off guard. While obtaining the history one may then detect a slight weakness. Careful watching of the feature folds of the mouth and cheek may bring out this important finding. I think the progression of the paralysis is the point indicating an expanding lesion.

3. *Optic discs and visual field symptoms.*—In most cases there will be some degree of blurring of the optic discs; this may be greater on the side of the lesion, though I have seen the reverse. The visual fields may show some contraction according to the variations in pressure. I believe however that disc and field changes are fairly late in frontal lobe lesions, but occur suddenly, once the pressure increases to a point where the interventricular foramen is bent enough to stop the circulation of the cerebrospinal fluid in the ipsilateral ventricle.

4. *Olfactory symptoms.*—I have had few cases in which I could be sure that there was much diagnostic value in the usual olfactory tests. However, Elsberg lays great stress upon the value of tests carried out by using coffee and citral as media.

5. *Changes in the reflexes.*—Reflexes may vary from normal, and the patient may show a Babinski or alteration of other named reflexes of the opposite side. These findings must be taken along with the other symptoms as additional evidence, and are then valuable.

6. *Ataxia and incoordination.*—These may be present, and appear to place the lesion in the opposite cerebellar hemisphere, and have been the cause of misdirected operations. However, ventriculography will immediately localize the lesion. Tremor of the opposite hand occurs occasionally. While I was preparing this paper a woman with a pronounced tremor presented herself, and I removed a small hard calcified mass from the right frontal lobe. It was pressing in front of and above the Sylvian vein.

7. *Forced grasping and groping.*—I have had no case which showed this phenomenon, but from the literature and the statements of others its presence appears to strongly suggest a frontal lobe lesion.

8. *Incontinence of urine.*—I have had several patients who had definite urinary disturbances with frontal lobe tumours. Foster Kennedy has drawn particular attention to this symptom occurring in frontal lobe lesions. However, it is valuable only as part of the whole picture.

9. *Unilateral exophthalmos.*—This occurs in some frontal lobe lesions. I have encountered this sign in one case of a meningeal fibroblastoma growing over the sphenoidal ridge forward over the floor of the anterior fossa. Others have drawn attention to this symptom.

10. *Speech disturbances.*—Always determine the handedness of the patient and stock. Aphasia is an excellent localizing symptom. But, the important point in early diagnosis is that the defect may first show itself as a slowing down in the speech, or a hesitancy, varying greatly from day to day.

11. *General convulsions.*—Seizures occur in a considerable number of frontal lobe lesions and, as explained before, should always give one reason to suspect a cerebral tumour.

PARIETAL LOBE:—

1. *Convulsions.*—Lesions here are probably the most likely to cause convulsions. The patients usually start with an aura, which may be sensory or motor, or they may complain of tingling or numbness in the opposite side. A man was referred to me who had sensory seizures for 8 or 9 years with some weakness of the left arm and leg. He complained of a mild headache and had a left homonymous hemianopsia. I removed an immense tumour weighing 178 grams (Fig. 2), occupying a large part of his right parieto-occipital region and attached to the falx.

2. *Changes in reflexes.*—There may be only a Babinski or there may be general hyper-reflexia.

3. *Sensory changes.*—Many patients complain of tingling or numbness but no objective findings can be brought out. If there are objective signs these are usually shown by alterations from normal in the patient's ability to discriminate distances of compass points, weights, and texture. There may be loss of the stereognostic sense (patients cannot name things placed in their hand). This test is not to be relied upon if there is loss of cutaneous sensation or if the patient is paralyzed in the hand or fingers.

4. *Aphasia.*—If the lesion is in the left cerebrum and adjacent to the Sylvian fissure the right-handed patient may have nominal aphasia (the loss of power to name things). He may then use other words to describe what he wishes to tell. Instead of saying "a match" he may say "to light with". A patient with a lesion in this region may find his way about, but would find it difficult to describe the course he would take. He usually lacks knowledge of the significance of words and phrases. For instance, after listening to an anecdote, if asked to repeat it, he would leave out important details.

TEMPORAL LOBE:—

1. *Visual field defects.* — Cushing has shown that there may be small sector field defects in the upper and outer quadrant. Right temporal lobe lesions are often very difficult to diagnose until they have reached a considerable size. These patients, according to Horrax, sometimes have a visual aura in seizures. The aura, because of its position, is of form and not of colour —the latter occurs in the occipital lobe. Sometimes the contralateral pupil is larger, or there is macropsia (that is, objects appear larger than they really are).

2. *Olfactory signs.*—If the lesion is in the antero-mesial surface of the lobe, the patient may complain of nauseating odours, and apparently they are always distinctly bad. One patient referred to me complained of the smell of a certain hospital. When he was admitted to hospital he immediately told the nurses the same smell existed. He had a left temporal lobe spongioblastoma multiforme. I removed as much of the tumour as I could and treated him by irradiation. He ceased complaining of the smell, but died within 7 months. One woman complained of a very nauseating odour, which, when she was questioned as to its description, she stated was like old menstrual blood. Her particular odour was followed by a seizure.

3. *Auditory disturbances.* — These occur further back in the temporal lobe, and there may be deafness. In a study of the brain tumours of the temporal lobe operated upon and proved by Penfield and Cone at the Montreal Neurological Institute, McNally and his co-workers noted that tinnitus was listed as a symptom in only 3 out of 17 cases.

4. *Dreamy states.*—Foster Kennedy, in beautiful language, has described the "sense of unreality" experienced by some of these persons. I have questioned two who experienced the curious feeling that they could sense something about to happen. They were able to gaze at the onlooker, and it appeared to them that he knew they were about to have a seizure, but at the same time their own criticism told them that the onlooker knew nothing of what was about to happen. Quickly following this, each had a general seizure.

5. *Paralysis.* — There may be contralateral lower facial weakness or if the lesion is larger, paralysis of the hand and arm in addition.

OCCIPITAL LOBE:—

Tumours of the occipital lobe alone are rare. Three of the 76 neoplasms mentioned in this article were in this situation.

1. *Homonymous hemianopsia.* — An examination of the visual fields shows a loss of vision of the opposite temporal field and the ipsilateral nasal field.

2. *Convulsions with visual aura.*—These patients have an aura of coloured lights. Often they present forms as a ring or vortex. A girl, aged 19, was referred to me with such a history, and examination revealed a homonymous hemianopsia with convulsions of a very violent

nature, preceded by an aura of red and orange-coloured rings which appeared to come and go. This phenomenon was located in the right temporal field. At operation I removed an astrocytoma with a cyst containing about 50 c.c. of xanthochromic fluid.

POSTERIOR FOSSA:—

The space beneath the tentorium is relatively small, and one would think that symptoms arising would make it fairly easy to diagnose these lesions early. But, it has been my experience that the general practitioner sends these cases later than any other. Of the 100 lesions listed earlier in this presentation 17 were in the posterior fossa; 13 were referred late. I believe the reason is that a number of these cases develop slowly and it is not until almost a complete block of the aqueduct of Sylvius or the fourth ventricle occurs that the symptoms become alarming. Then, they may occur with terrorizing suddenness. Something has to be done; unfortunately it is sometimes a spinal puncture. However, a careful examination of most of these cases will bring out early symptoms. These early symptoms are naturally the result of disturbed function of the cerebellum which conserves coordination and tone.

1. *Ataxia.*—Because they have lost some control of coordinating the movements of the leg muscles, the patients are unsteady, and often sway in a drunken fashion. They usually walk with the feet wide apart, to increase the base around their centre of gravity. They may fall or walk to one side; this often indicates the side of the lesion. A farmer gave me a history of inability to follow a plow in a furrow; he constantly walked into the unplowed side of the furrow.

2. *Lack of coordination.* — Most cases show some lack of coordination. Finger to nose tests in which the patient misses the object, or heel-knee-shin tests can be used; the disabled side shows the manœuvre poorly performed. If the arms are held straight out the one on the altered side may fall slowly away without the patient being aware of it. Inability to perform rapid movements, such as rotating the hands or patting the bed with each hand, may also bring out failing function. I have found it well to carry out these tests on various visits to these patients and to vary them as much as possible. If there is actual loss of coordination I think it can almost always be demonstrated.

3. *Position of the head.*—I have seen a few patients hold the head in a particular position. The usual one described is where the head is flexed toward the shoulder upon the side of the lesion, and the chin towards the opposite shoulder. One of my patients with a very deep right cerebellar tumour developed a severe degree of head retraction with opisthotonus.

4. *Nystagmus.*—This occurs in tumours of the cerebellum and I believe Sachs is correct that it indicates a tumour deep enough to be in contact with the cerebellar nuclei. The nystagmus may be in both directions. I have had one case with nystagmus both vertical and lateral; the tumour completely blocked the fourth ventricle and encroached upon the right cerebellar lobe. The vertical component disappeared first during convalescence.

5. *Convulsions.* — Cerebellar fits occurred in my series only once. This was in a case of cystic arachnoiditis, a young man 25 years of age. He would become very excited and move his limbs rapidly, and usually fell backwards, but remained conscious.

6. *Cranial nerve palsies.*—There may be paralysis of the nerves emerging from the medulla —the 9th, 10th, 11th and 12th nerves. Tumours involving the 8th nerve may also paralyze the 7th nerve or the 5th nerve.

OTHER METHODS OF DIAGNOSIS

Spinal puncture.—In spite of the fact that almost universally neurosurgeons condemn the practice of carrying out a spinal puncture in the presence of increased intracranial pressure, yet it is being done frequently. Sudden death may have been stressed too much, and not the fact that the result of a spinal puncture may only start œdema of the medulla, which continues and may end the patient's existence as much as two weeks later. One patient I had referred to me had been punctured two days before, and although carefully done the procedure was followed by increase of symptoms. I carried out a ventricular puncture and diagnosed a right parietal brain tumour. At operation the tumour was removed without any difficulty, but from the very time of the puncture there was a definite upset of the length and depth of respiration. He succumbed ten days after the operation of definite respiratory failure. I believe the way to change an early diagnosis of an expanding lesion of the brain to a late diagnosis is to carry out a spinal puncture.

X-ray examinations of the skull.—Early diagnosis of a considerable number of lesions can be made by stereo films of the skull. I think a careful systematic study of these often shows the presence of a lesion. I usually look for (*a*) skull rarefactions, or convolutional atrophy, or areas of definite thickening or widening of the sutures; (*b*) excessive vascularization; (*c*) atrophy of the floor of the anterior fossa, or ophthalmic foramen changes; sella turcica changes—atrophy, "ballooning", loss of clinoid processes; changes in the porus acousticus; actual atrophy of the occipital bone; (*d*) calcification within a tumour (Fig. 3), or shift of the pineal calcification, or of calcification in the falx.

Ventriculography (Figs. 4, 5 and 6).—By this procedure the ventricular system is more or less filled with gas, either air, oxygen, or ethylene, and films are taken in various positions, after considerable careful manipulation. There is no doubt the exact location of expanding lesions of the brain can be diagnosed in over 95 per cent of cases. But at times the interpretation is not easy, and great care must be taken not to be misled, especially by non-filling (Fig. 5) of some parts of the ventricular system. Personally I never use spinal injection of gas to diagnose expanding lesions of the brain.

Early diagnosis of expanding lesions of the brain is chiefly a matter of careful, studious examination of the patient following a definite plan. But, as a last word, I would say send a case early as a suspected lesion, rather than an absolutely localized brain tumour late.

SUMMARY

1. An attempt has been made to explain what is meant by early diagnosis.
2. The actual mechanics of intracranial symptoms has been dealt with briefly.
3. Symptoms have been explained under the captions of (*a*) general, and (*b*) focal, the latter referring to the lobes and the cerebellum.
4. Other diagnostic means: (*a*) spinal puncture; (*b*) x-ray examination of the skull; and (*c*) ventriculography, have been referred to.

A lengthy bibliography has been prepared and may be obtained on application to the author.

EXTERNAL HYDROCEPHALUS*

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HYDROCEPHALUS, or "water on the brain", consists of an accumulation of cerebrospinal fluid in the cranial cavity. The strict interpretation of the term includes any increase of fluid in the brain but the clinical entity understood is restricted to a progressive accumulation of fluid. This eliminates consideration of transient and sudden increase in cerebrospinal fluid that occurs in head injuries, cerebral inflammations, in space compensation, and chronic transudation of fluid in vascular hypertension.

Hydrocephalus is always caused by an obstruction that prevents the passage of cerebrospinal fluid from its place of formation in the ventricular system to its place of absorption in the subarachnoid space. The location and the character of the block vary greatly. Obstruction may be in the ventricular system or in the subarachnoid space or both. There are three general types of obstruction: (1) congenital malformations, (2) tumours and other space-occupying lesions, and (3) inflammatory sequelæ. The usual congenital conditions causing hydrocephalus are: (1) atresia of the aqueduct of Sylvius, (2) failure of the foramina of Magendie and of Luschka to develop, and (3) failure of the subarachnoid space to become patent.

Internal hydrocephalus is a fairly common condition and usually consists of an excess of fluid in both lateral ventricles. It often develops in fetal life or shortly after birth. When it is present before the sutures have ossified the head often becomes enormously enlarged, the interosseous sutures are spread apart, and the fontanelles are patent. The ventricles are extremely distended and the brain walls are stretched and atrophied (white matter chiefly) until they become little more than a thin membrane.

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